

OpenMRS, A Global Medical Records System Collaborative: Factors Influencing Successful Implementation

Nareesa A. Mohammed-Rajput, MD, MPH^{1,2}, Dawn C. Smith, MPH, CHES¹,
Burke Mamlin, MD, MS^{1,2}, Paul Biondich MD, MS^{1,2}, and Brad N. Doebbeling, MD,
MSc^{1,2,3}, for the Open MRS Collaborative Investigators
¹Regenstrief Institute, Inc., Indianapolis, IN, ²Indiana University School of Medicine,
Indianapolis, IN; ⁴Center for Implementing Evidence-based Practice, Roudebush VA
Medical Center, Indianapolis, IN.

Abstract

OpenMRS is an open-source, robust electronic health record (EHR) platform that is supported by a large global network and used in over forty countries. We explored what factors lead to successful implementation of OpenMRS in resource constrained settings. Data sources included in-person and telephone key informant interviews, focus groups and responses to an electronic survey from 10 sites in 7 countries. Qualitative data was coded through independent coding, discussion and consensus. The most common perceived benefits of implementation were for providing clinical care, reporting to funders, managing operations and research. Successful implementation factors include securing adequate infrastructure, and sociotechnical system factors, particularly adequate staffing, computers, and ability to use software. Strategic and tactical planning were successful strategies, including understanding and addressing the infrastructure and human costs involved, training or hiring personnel technically capable of modifying the software and integrating it into the daily work flow to meet clinicians' needs.

Introduction

Global Health and resource-constrained environments

The increasing recognition of important health needs in developing countries, increasing attention by global funding agencies and foundations, and emergence of global health informatics has galvanized the dissemination and utilization of electronic health technology throughout the world. One of the major service gaps in this area, however, is apparent in resource-constrained environments. As previous research indicates, developing countries not only suffer from the greatest burden of infectious diseases such as human immunodeficiency virus (HIV) and tuberculosis (TB), but these resource-constrained environments also lack both the organizational (or internal) environment and the sociotechnical system resources (adequately trained personnel, reliable electricity, computer equipment, software) to adapt tools to fit the local environment and manage the case loads¹. These challenges arise from multiple factors including unsustainable financial economies, epidemics, civil war, even natural disasters, such as droughts.

In addition, resource-constrained countries typically do not have robust healthcare infrastructure which contributes to a lack of continuity of patient care. Implementing an electronic medical record system in a resource constrained health care system can help reduce medical errors and improve quality of care delivery by using functions such as computerized order entry and clinical decision support.¹

OpenMRS

In 2004, two faculty members with the Indiana University School of Medicine, conceptualized and did initial development work on a new patient record system to support one of the largest HIV/AIDS health systems strengthening initiatives in western Kenya.² Over the next year, they fostered collaboration with another similar initiative called Partners-in-Health, and this gave rise to an emergent open source community. That initial record

system for Western Kenya (the AMPATH Medical Record System – AMRS), was deployed in 2006 and today supports the record keeping for over 300,000 patients. Beyond the sites in Western Kenya, the underlying OpenMRS platform now extends into at least forty countries worldwide. Today, OpenMRS is an open-source electronic health record platform that stores and functions against comprehensive longitudinal patient data. It is freely available, requires minimal, if any, programming experience to set up and is supported by a large global network of developers and implementers³. What initially began as a record system to support hundreds of patients' data now stands as a robust platform that supports hundreds of thousands of individuals receiving comprehensive health care.

Purpose of the Project

The initial implementation and utilization of OpenMRS in Eldoret, Kenya, resulted in successful implementations of the software in developing countries throughout the world. Behind each implementation, however, exists an unique story of processes that encompass specific challenges, solutions, and successes. This paper examines those experiences of OpenMRS implementers who work in resource constrained settings throughout the world, in order to draw conclusions regarding factors stimulating implementation, barriers and facilitators to implementation, and successful strategies for implementation and sustainability.

Methods

Data Collection

This process began with reviewing existing data and planning multimethod, qualitative and quantitative, data collection to answer the study goals. Initially, purposive sampling was used, specifically selecting individuals from organizations who were known by the developers to have implemented the OpenMRS software. Within this sample, we collected data using both random and key informant methods. The reasoning behind these data collection approaches came specifically from concerns in regard to accessibility of the study population. Challenges to accessibility include lack of information regarding implementation sites, a global community, and resource constraints.

The OpenMRS site dedicates a webpage to the known implementations occurring throughout the world. However, as evident through inquiries made of the implementers' mailing list, participants do not always report their work in implementation and may be left unknown. Due to the expansive global community, geographical location and language differences also represent a barrier. Figure 1 is a graphical representation of known sites using OpenMRS.

In order to connect with individuals throughout the world, communication modes such as telephone, Skype®, and/or email represent ideal solutions both in terms of cost and response time. These methods represent ideal solutions; however, many implementation sites occur in resource-constrained settings that lack simple infrastructure such as consistent electricity. Furthermore, many sites had limited internet or network capability, some requiring dial-up modem access. This was a barrier to written questionnaires, with graphics, as well as the time to download and upload structured data. Thus, we used data from a variety of sources, in order to get as complete a picture as possible regarding the spectrum of experiences in implementation, usability and sustainability.

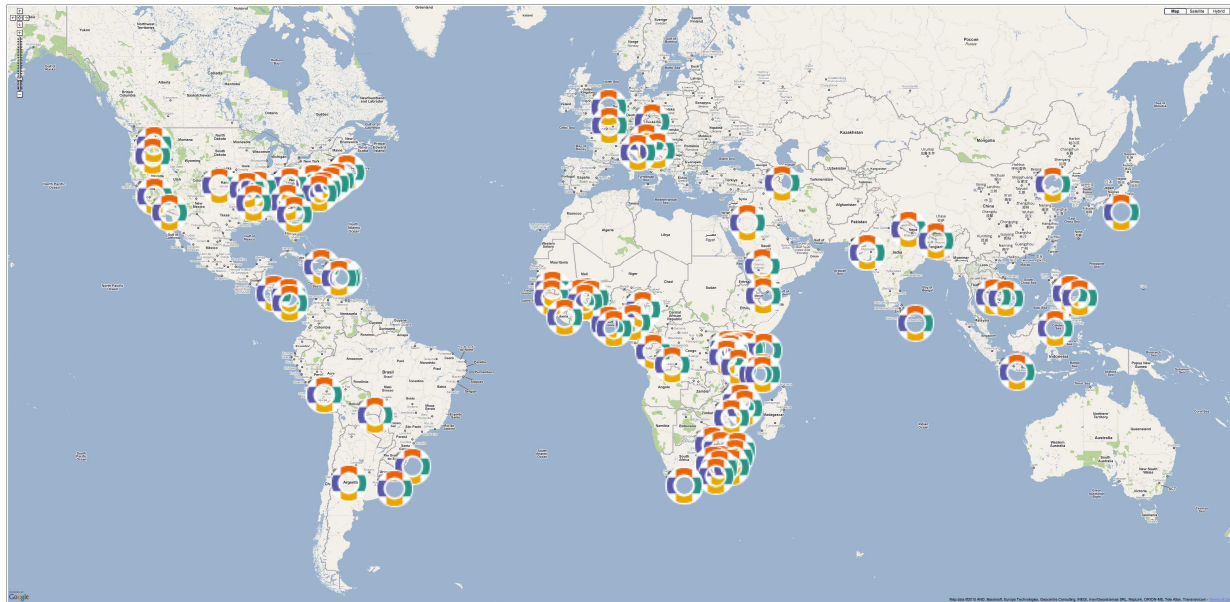


Figure 1 - Map of known OpenMRS Implementations⁴

Anticipating these challenges, we collected data through various avenues which included individual interviews at the annual OpenMRS Implementers Meeting, disseminating an electronic survey through both individual email and the implementers mailing list, utilization of previous, relevant data from OpenMRS implementation sites documented on the OpenMRS website, and when possible, Skype® and telephone interviews.

Survey Development

Construction of the survey was based on experience in survey development, previous discussions from individual implementers in the community, as well as concepts from implementation science and experience in assessing the implementation of clinical decision support and EHRs in multiple other settings^{5,6,7}. From those discussions, we framed the survey into four parts which included information about the implementer, the implementation itself, upgrades to the software, and evaluation. Within the survey itself, we specifically utilized open-ended questions to elicit as much data and detailed responses as possible. The questions covered mechanisms and best practices used to facilitate EHR implementation and integration into workflow.

The structure of the survey was reviewed, discussed and refined by several of the study authors. The survey was developed as a tool to inform the further development and spread of OpenMRS. It was developed by informatics experts and modified based on feedback from other content experts to guide further training and implementation efforts. The survey also pointed to classes of barriers and facilitators to EHR implementation reported elsewhere. Thus, it was judged by the developers to have content and face validity.

We identified a key respondent at each of 10 sites to participate in the survey. We examined data from sites with that had already implemented and used the software and had experience in incorporating it in their existing workflow and processes. There was some variation in the breadth of implementation, in that different sites did implement some or many of the different modules, but all had experience with a core set of modules.

Coding

Once we received responses, two of the researchers began coding the same surveys. Each researcher independently coded each survey by attaching phrases to represent key words or concepts within the responses for each question. After the initial coding the team came together and went through each response to find commonalities in coding between each researcher.^{8,9} The coding template (or codebook) was modified as coding proceeded, themes emerged

from the data, and findings were integrated across sites into meaningful patterns. For any discrepancies, the coding process was discussed until a consensus was reached. After discussion, the documents were recoded using the agreed upon process and the investigators moved on to code additional documents. Following coding, the coders reviewed, discussed, and reached consensus on coding before moving to the next portion of data.

Results

A total of 10 sites participated, representing 7 countries. The sites ranged in size from large (95,000 patients) to small (450 patients). They had a mix of users (ranging from 3 to over 350) including clinical (60%) and non-clinical staff such as data entry clerks (100%). The most common tasks that users performed were data entry and data reporting. Others included patient care, system maintenance, data export, forms development, data quality and accuracy review, clinical summaries, and clinical laboratory alerting and administration and patient registration. The most common workflow was the clinicians using paper forms to document a clinical encounter. Then the data entry clerks enter the information from the paper forms into OpenMRS for future use.

The participating sites could report more than one reason for implementing OpenMRS. Reasons for implementation include reporting to funders, use for clinical research, and clinical care. Most organizations planned to use OpenMRS to assist with supply chain management (such as ordering medical supplies, medications, vaccines, etc) and logistics (**Table 1**).

Table 1 - Reason/benefits of implementing OpenMRS

Reason/Benefit of Implementation	Number of Sites (Out of 10 Sites)
Reporting to Ministry of Health	1
Research	8
Management/Logistics	6
Reporting to Funders	8
Clinical Care	8

The sites represented by the survey are shown in Table 2. Most of the participating sites were from the continent of Africa. Sites varied dramatically in terms of the estimated number of patients, and reported users. User roles included particularly data entry and reporting. Tasks also varied across sites, but most used the system for patient care and reporting.

Table 2 – Sites represented by survey

Countries	# Patients (approximate)	# Users	Users roles	Tasks performed
Kenya	45000	350+	Clinical providers, data managers, data assistants, system managers	Patient care, data export and reporting, data entry, system maintenance
South Africa	95000	6	Administrator, nurse, supervisor	Administration, consultations,

				patient registration
Kenya	500	3-5	Registration, data entry, reporting	registration, data entry, reporting
Rwanda	500	3-5	registration data entry, reporting	registration, data entry, reporting
Lesotho	450	3	system developer, data entry	data entry, reporting
Tanzania	8433	3-6	data entry, data manager, clinician	data entry, reporting
Uganda	4000	4	developer, data manager	forms development, data entry, reporting
Malawi	1500	25	registration, nurse, vitals clerk, clinician, pharmacist, administrator	data entry
South Africa	4000	20	data entry, data managers, physicians, researchers	data entry, data export, reporting
Rwanda	5842	184	system developers, data manager, data assistant, data entry, clinicians	data entry, data quality and accuracy review, reporting, clinical summaries, laboratory alerts

After coding the data and reviewing the responses, patterns in the responses across various implementation sites began to appear. We focused the analysis of data on five key five questions. We chose these questions because the content focused specifically on generalizable issues related to factors impacting the successful implementation of EHRs, and which had the greatest breadth and depth of content in these areas.

These questions included the following: 1) how the organization selected OpenMRS, 2) challenges faced during implementation, 3) advice to new implementers, 4) successful approaches to implementing OpenMRS, 5) describe your professional background, any training, previous work experiences. We found through analyses of the challenges experienced during implementations, that the implementer's background and experience also played a role in the successful implementation, or lack thereof, of OpenMRS. Further, successful implementations rely on an intricate network composed of individuals with relevant interdisciplinary training and adequate infrastructure.

How Organizations Selected OpenMRS

What we hypothesized in research design was that most organizations learned about OpenMRS through their own social networking, research or from a collaborating organization already utilizing the software. Among the participants, the selection of OpenMRS as a solution to managing patient medical records arose from two common threads: 1) the organization already utilized OpenMRS when the individual started working as an implementer, and 2) through its international recognition, the respondent (or organization) learned about OpenMRS from other individuals. These responses were consistent with our *a priori* hypotheses to a certain extent.

However, we also found that it was important to consider the phase at which different healthcare organizations were in the implementation process. Some organizations had not yet implemented, therefore were in the planning phase. Other implementers reported that the implementation process had occurred months to years before their employment and lacked the knowledge of how that implementation initially began. Still other individuals, who may not have been present during the initial EHR implementation, supported the upgrade in the software version (ex. supporting 1.6 and upgrading to 1.7). We considered the responses of all these individuals in providing insight into the process, regardless of the stage in implementation of the organization.

Challenges Faced During Implementation

A variety of challenges appeared during data collection, some of which were commonly shared across implementation sites and others that were specific to a particular setting.

Electricity - This represented the most common challenge during implementation and was identified as the first response in most of the participants. The range of structural issues with adequacy of electricity supply encompassed both the costs and supplies for electrical solution such as solar solutions and equipment, generators, and batteries. This only represents the surface of a deeper set of issues due to the dependency that implementation sites have on electricity for daily work flow. Lack of reliable electricity impacts computer use, lights, and internet capabilities. Further, many sites noted the importance of the issue of losing information during a power outage.

“The setback of not having constant electricity and internet at all health facilities means that sometimes data does not get synched back in time to the main server and especially for laboratory data that needs to be sent back to the individual health centers”

Incomplete Data - Whether due to a power outage, human error, decentralized data and sites, incomplete data impacted the process of implementation due to gaps in information. Incomplete data also negatively influenced the ability to report to Ministries of Health and other funding sources.

“The other problem is that not all clinicians fill out the forms completely, which leads to incomplete data in the EMR.”

Staffing Issues – The adequacy of the educational background, training, and work experience of staff directly involved in the implementation also represented a key challenge that organizations faced. Within this study, one half of the individuals who responded to the question about their educational background reported that they held a medical degree. In the sample, there was one computer science degree and one informatics degree.

“It works/will work at these heavily supported sites but scaling to other sites without the same capacity in IT personnel and hardware would be a challenge”

Funding - While the software itself is free, in addition to access for the mailing lists on the OpenMRS website, on-the-ground support to actually build up the infrastructure needed on site requires finances. Currently, estimates on the cost of implementing OpenMRS do not exist.

“What are the main challenges to making it work? Funding, human resources (programmers)”

Software limitations - The software is not a complete electronic medical record (EMR) and does not currently have all the functionality that many commercial EMRs have. Some sites felt that although OpenMRS met most of their needs, there was some key functionality that was needed for their sites that was missing. Also, because of the modularity of OpenMRS, and lack of redundancy and backup of the computer systems at sites, there are some bugs in getting all modules to work together seamlessly.

“..program bugs, lack of features, getting clinical staff to properly use forms, clunky interface, explaining to staff why paper is entered through forms eg. what is directly entered and why.”

Documentation – Respondents noted that additional guidelines or a “how to” on the implementation process, in addition to any notes for troubleshooting would be valuable. Implementers can post any questions to the mailing list in regard to challenges with the implementation, but a challenge within that is that sites may be in different stages (planning, implementation, upgrading) of the experience.

“ [There is] lack of good documentation online [at OpenMRS]- especially for implementers.”

Discussion

Factors Influencing Successful Implementations

Analysis of the data reported herein demonstrates that successful implementations tend to fall within one of several categories which fall within the dimensions of the sociotechnical systems model. Important dimensions we identified include external environment, adequate organizational infrastructure (power, hardware.....) and adequacy of technical and social systems, such as trained personnel who can provide support.

Barriers and challenges to effective EHR implementation and use are common across the social, technical, and external subsystems.¹⁰ Further, multiple dimensions of the sociotechnical system, such as adequacy of personnel, training and software support are also important barriers.

In terms of infrastructure, this is a common and significant challenge due to the resource-constrained environments seen within the OpenMRS community, and an element that may be out of the control of individuals in that environment. These include inadequate computer technology, slow internet connections, intermittent power supplies, inadequate databases, and even limitations in the software.

Adequacy of staffing and training occurs both with employed individuals lacking experience in computer science and/or informatics and also providing opportunities for training of presently employed individuals to better understand the implementation process, adaptation of the system to fit the local environment and clinicians and the systems clinical and operational workflow.

These findings build upon and extend the findings of others using a variety of different conceptual frameworks and methods. DeLone and McLean have constructed a multidimensional model of successful implementations, which has six dimensions: systems quality (or technical success), information quality (or semantic success), service quality, use, user satisfaction and user impacts and organizational impacts (net benefits).¹¹ They suggest that as a result of using the system, benefits will occur. These net benefits will impact user satisfaction and use of the system. Our findings are completely consistent with this framework.

Heeks also discussed the design-reality gap model, which would reduce health information technology implementation failure both in the pre-implementation stages and the post-implementation stages.¹² Here, success and failure depend upon the size of the gap that exists between “current realities” and desired “design”. Brender et al categorize success and failure criteria of EHR implementation into six categories: functional, organizational, technical, managerial, cultural and legal.¹³ Brender and colleagues’ review concluded that a successful implementation of a healthcare information system cannot be analyzed by only one theory or factor, but needs many interrelated and emergent factors.

A few solutions which implementers have utilized to support infrastructure include the use of generators and solar panels for energy. In terms of understanding the hardware and software alike, a common solution is utilizing someone on staff or hiring individuals with experience or expertise in this area.

Conclusions

Overall, we found that strategic and tactical planning were key to success in EHR implementation in resource-constrained environments. Factors which might not even be considered in resource-rich countries can loom large in influencing the successful use of EHRs in resource-constrained ones. Successful strategies, included understanding

and addressing the needed infrastructure and human costs involved, training current personnel or hiring personnel who understand the software and how to modify it, and integration of the system into the daily work flow and meeting clinicians' workflow needs.

Acknowledgements

We would like to thank Dr. Zeshan Rajput and the rest of the OpenMRS community for their support. This work was performed at the Regenstrief Institute, Indianapolis, IN, and was supported in part by grant 5T15LM007117-14 from the National Library of Medicine (NLM) Fellowship Program (Dr. Mohammed-Rajput), Regenstrief Institute, Inc. and Department of Veterans Affairs, Veterans Health Administration, Health Services Research and Development Service HFP 04-148. Dr. Doebling is a Senior Research Scientist at the Richard L. Roudebush VA Medical Center in Indianapolis, IN.

References

- ¹Williams F, Boren SA. The role of the electronic medical record (EMR) in care delivery development in developing countries: a systematic review. *Informatics in Primary Care*. 2008;16(2):139-45.
- ²Tierney WM, Rotich JK, Hannan TJ, Siika AM, Biondich PG, Mamlin BW, et al. The AMPATH medical record system: creating, implementing, and sustaining an electronic medical record system to support HIV/AIDS care in western Kenya. *Stud Health Technol Inform*. 2007;129(Pt 1):372-6.
- ³Mamlin BW, Biondich PG, Wolfe BA, Fraser H, Jazayeri D, Allen C, et al. Cooking up an open source EMR for developing countries: OpenMRS - a recipe for successful collaboration. *AMIA Annu Symp Proc*. 2006:529-33.
- ⁴<http://openmrs.org/about/locations/>. (Accessed March 8, 2011).
- ⁵Doebling, B.N., Chou, A.F., Tierney, W.M. Priorities and Strategies for Implementation of an Integrated Informatics and Communications Technology System for Evidence-based Practices. VHA State of the Art Conference (SOTA) VII. Implementing the Evidence: Transforming Practices, Systems, and Organizations. *J. Gen. Intern. Med*. 21:S98-S105, 2006. PMID: 16637961
- ⁶Doebling, B.N., Vaughn, T.E., McCoy, K.D., Glassman, P. Informatics Implementation in the Veterans Health Administration (VHA) Healthcare System to Improve Quality of Care. *AMIA Annu Symp Proc* 204-208, 2006
- ⁷Flanagan, M.E., Patterson, E.S., Frankel, R.M., and Doebling, B.N., Evaluation of a Physician Informatics Tool to Improve Patient Handoffs, *J Am Med Inform Assoc*, 16:509-515, 2009. PMID: 19390111
- ⁸Ash, J.S., Smith, A.C., Stavri, P.Z. In: Friedman CP, Wyatt JC, editors. Performing subjectivist studies in the qualitative traditions responsive to users. In *evaluation methods in biomedical informatics*. 2nd ed. New York: Springer; 2006. p. 267-300.
- ⁹Richards, L. & Morse, J.M. (2007). *Users' guide to qualitative methods*. 2nd ed. Thousand Oaks: Sage.
- ¹⁰Xiao Y, Vicente KJ. A framework for epistemological analysis in empirical (laboratory and field) studies. *Hum Factors*, pp. 42:87-101, 2000.
- ¹¹DeLone WH and McLean ER. The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. *Journal of Management Information Systems*, 19(4): 9-30, 2003.
- ¹²Heeks R. Health information systems: Failure, success and improvisation. *International Journal of Medical Informatics*, 75(2): 125-137, 2006.
- ¹³Brender J, Ammenwerth E, Nykanen P and Talmon J. Factors Influencing Success and Failure of Health Informatics Systems: A Pilot Delphi Study. *Methods Inf Med* 2006; 45: 125-136.

Appendix 1 – Survey

Part I – The Implementer

1. What is your name?
2. What is your email?
 - a. Is it okay if we share/publish your e-mail address?
3. What organization do you work for?
4. Where is your organization located?
5. How long have you been with this organization?
6. What does your organization do?
7. How did you come to work for your current organization?
 - a. Describe your professional background, any training, previous work experiences
8. How did you receive your role as an implementer of OpenMRS?
9. How did your organization choose OpenMRS?

Part II - The Implementation

10. When did you first implement OpenMRS (year and version)?
11. What version of OpenMRS are you currently running?
12. How does your organization use OpenMRS?
13. How did you go about the implementation process?
14. What are some of your experiences regarding challenges implementing OpenMRS?
15. How would you improve the implementation process?
16. If you were going to advise someone new on implementing OpenMRS, what would you tell them?
17. If you have difficulties during your implementation of OpenMRS, where do you seek advice or counsel?
18. What functionality do you currently use in OpenMRS?
19. What functionality is missing in the current version of OpenMRS?

Part III - Upgrades

20. Have you ever upgraded OpenMRS to a newer version?
21. What difficulties have you had in upgrading OpenMRS to a newer version?

Part IV – Evaluation

22. Have you evaluated your implementation of OpenMRS in any way? If so, what have you done?